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AUGUST 15, 1919

AVIATION AND AERONAUTICAL ENGINEERING

VOL. VII. NO. 2

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BUSINESS MANAGER

Vol. VII

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No. 2

THE bill providing for the organization of the Air Service and for the creation of an air department in the form of an executive agency of the Government, which Senator Harry S. New has brought before Congress, is by far the most comprehensive and well thought out measure that has been proposed with a view to further American aviation.

The field of action assigned to the proposed air department is sufficiently ample to provide for any emergency that might come up in connection with the maintenance and up-to-date development of our air force and the creation of a merchant air force, with the necessary air ports, supply depots, etc. In the words of the New bill, the air department would be "charged with all matters pertaining to aeronautics for the Army and Navy, Post Office Department, Coast Guard, or any other department of Government in terms of peace and war, for the improvement and development of the science of aeronautics as may be deemed desirable in the public interest, for the purpose of extending commerce, and for such other affiliation as may work to the betterment of the country."

The one great objection which is often made against an independent air force, namely, that the assignment of aeronautical units for tactical employment with the Army and the Navy on the basis of cooperation, that is, without effectual control on the part of the military and naval commanders concerned, would lead to inefficiency is answered in the New bill with a provision to the effect that "the tactical employment of all such units while so assigned shall be under the exclusive control of appropriate military and naval commanders." Hence this objection falls to the ground.

From the viewpoint of commercial aeronautics the creation of a separate air department commands itself with particular forcefulness. The conviction is daily gaining ground that aerial transport services will not come into being until what the French call the "infrastructure"—that is, air routes provided with suitable landing grounds and properly marked for day and night flying—are organized. An organization of this sort is an undertaking of such magnitude that it surpasses the powers of the aircraft industry. A promising beginning has already been made by various cities with the establishment of municipal aerodromes, but it seems that this work should be supervised by the Government so as to insure certain safety requirements and general coordination. An air department would be the proper agency for this kind of work and it should be within its powers to also create a federal air code and

thus prevent the threatened individual air legislation by forty-eight states, which would kill aerial transportation in its infancy.

Still another field of activity where an air department could exert healthy influence would be in the licensing, registering and inspecting of aircraft, and the licensing of pilots—which again should be a federal prerogative. The experience of State automobile legislation should be a sufficient warning in this respect.

Finally, not the least important duty of an air department should be the creation of a central aeronautical establishment where aircraft would be tested, both statically and in full flight, before being given a license to carry passengers, and general research and development work would be conducted with respect to aerodynamics and materials of construction.

It may be seen that an immense field of activity awaits a government agency that would have within its attributes the centralization, control and development of aeronautics in all of its applications.

Skow Skids

An important problem which confronts the designer of transport airplanes is the provision for a landing gear which will permit safe get-away and landing on snow-covered fields.

Since it is impossible to know whether an open or a snow-covered field awaits the pilot, the ordinary land chassis must remain intact, and moreover, no ordinary action must not be impeded by the snow skids. They must be high enough so the wheel base will not touch the ground in ordinary taxiing or get-away.

The action of a skid on landing is in some ways analogous to that of a piston. In yielding water the piston has some provision of a V-shaped bottom to minimize the first initial shock, as most the skid. When the V has sunk in, the skid must provide a broad bearing surface so that the pressure is not too great, as otherwise immediate stoppage and terrible stresses will be set up. The skid must be long enough and shaped as such a manner that there is no tendency to tilt over.

On get-away similar conditions have to be fulfilled. However, the skid cannot merely be a flat surface. It has to be a back-like structure, with sufficient strength to stand stresses, even though it has not to provide the buoyancy of a water-borne machine.

These and other points offer a fruitful problem for the designer, and usage in the field will soon indicate defects and their remedies.

The cloth is very carefully supported after manufacture, both before and after such treatment as denning and washing. All cloth and imperfect spots are marked so that they may be cut out before relubricating. In the rubber furnace the cloth is first passed through spreading machines, where the coats of dough (rubber cut with shaved needles and rubber rollers) are applied. Carefully selected pure gum is used for this purpose, and there is added only a very minute percentage of sulphur and linseed oil without the usual separate cure accelerators previously used. This thin rubber solution fills up the crevices of the weave. Much heavier rubber

of the thin character of the solution required for successful pressing.

The inner or gas side of the fabric is coated with foam rubber to one ounce of pure rubber, which helps to keep the cloth taut and moisture-proof, reduces friction, and makes a good sliding seal for successful testing.

The exterior and interior seams have been made fairly wide (2 in. or 2 1/2 in.), and contain a substantial amount of proofing. The exterior tape has an aluminum facing. Both tapes are sewn out or the seam so that stretch may occur.

The seams in the envelopes of non-rigid blimps constructed



FIG. 7. AKRON C-2. THE AIR IN SUPPORTER AS AN EXPERIMENTAL HOISTING PATCH HANGING

though is then applied on the spreading machines on the pressure grounds. After twenty to twenty-five coats are spread and dried, a gas-tight film is produced.

The gas-tightness depends, however, upon such factors as the thickness of the rubber proofing and the nature of the cloth, high tensile cloth and heavy proofing giving the maximum efficiency. For instance, with 2-ply 30-lb cloth having a gas film of from 25 to 4 in., there is obtained very low diffusion. Added weights of proofing applied to higher count cloth would probably produce but slightly better results than are obtained with the above construction. Two pairs of the treated cloth are stuck together by means of multi-ply machines. The fabric is then wound on drums, wrapped and stored under carefully controlled temperature and pressure.

Chemical-analysis results in a fabric that ages rapidly, becoming brittle and stiff upon exposure. Examination of such fabrics upon exposure immediately shows high diffusion and rapid loss in service strength (indicating great oxidation). An acid smell is always observed, and the rubber between the plies is hard and shows a lack of its original adhesive properties. Under-oxidation is therefore the lesser evil, since exposure to the air and sun causes a certain degree of auto-oxidation.

Yellow and red exposure dyes are stable in capsules are often added to the proofing gum. These dyes are because they rapidly decompose throughout the rubber addition and act as light screens in preventing the admission of sunlight to the rubber proofing. Yellow Cadmate Sulphide pigment is also used for this purpose.

The exterior surface of the fabric is coated with pure gum rubber dough containing usually a substantial proportion of linseed oil, which has been found to act as a sealer or filler in facilitating the admission of light rays to the rubber proofing. To the same exterior dough coating a quantity of finely divided aluminum powder is added, and this spread on the outer face of the exterior of the fabric. The aluminum powder is a reflecting seal. Fabrics made with such a coating have proved to be efficient in this respect, retaining usually 25 to 30 deg. Fahr. lower on immersion than similar fabrics without the aluminum facing. This aluminum seal is usually applied either with a spreader or a rubber proofing roll. In the latter case a larger number of coats are usually necessary on account

of the fact that the pure gum cement consisting of adroit and the pure rubber pulp. A count of this character is usually satisfactory when the temperature is below the average is exposed rarely reach 55 deg.; but it was found that with the high temperatures prevailing in the United States during the summer this count could not be depended on. General surface covered, and the strength of the main was reduced to the strength of the covering, which is far below the strength of the fabric used in making the balloon. One remedy, to overcome this difficulty, consisted a certain amount of resin into the cement which acted as a hardening agent. Even this was apparently insufficient, for when tested in an oven at a temperature of from 100 deg. Fahr., the same made with this cement showed a tendency to slip on account of the softening of the cement. Another contractor who had accepted the airship problem of using a strictly pure gum cement encountered great difficulties with the entire envelope on account of softening of the cement. He investigated this problem very thoroughly, and finally developed a method of softening the pure gum cement with a semi-cured solution, with the result that the same apparently held up in temperatures of 150 deg. Fahr. without appreciable softening. This practice is considered to be an experiment suggested.

(To be continued)

Giant British Airship

The British Government has begun the construction of the largest airship that has not been undertaken in any part of the world, one that will carry an equivalent of an airplane for its own propulsion against the wind—class air craft, according to recent reports.

This airship and the two kangers to be built for it will weigh 60,000,000 lb. It will have a capacity of 30,000,000 cu. ft., will be 3100 ft. long, 127 ft. in diameter, and capable of lifting 100 tons. This weight will be about five times the lifting capacity of the R.101, which has just made a record trip across the Atlantic. The airship will be ready for the test, which will be finished in five months to twenty months, in green as 20,000 miles.

The Aerodynamic Experimental Tunnel

By W. Knight

The study of the forces acting on the different parts of an airplane during its flight is positively carried out in an experimental way on reduced size models of the parts to be investigated. This may be accomplished either by keeping the body stationary as a current of air which is moving at a velocity equal to that of the airplane in flight, or by moving the body, at the same velocity, through static atmosphere.

It is evident that the first method is the more convenient of the two, and immediately feasible are built on this principle. A current of air of desired velocity is produced by means of a fan, and this current is directed into a tunnel in which the parts to be experimented upon are conveniently supported by



Fig. 1 (Closed)



Fig. 2 (Open)



Fig. 3 (Closed)



Fig. 4 (Open)

a suitable arrangement of levers and spring balances which measure the forces and the moments created by the air current striking the body.

It is also to be noted that the guiding principle to be followed in designing an aerodynamic tunnel, is to obtain the desired air velocity with a minimum amount of power in a tunnel which is large enough to contain the parts under investigation.

Captain H. Coatsworth and Colonel G. A. Crooke of the British Army, carried out a series of experiments on several models of various shapes, in order to determine the best design to adopt in a tunnel. The results of these experiments are given in the following table. The conclusions reached by Captain Coatsworth and Colonel Crooke, will be briefly presented in the present article.

Captain Coatsworth experimented upon various shapes of various shapes, and compared the power required at different air velocities in a given series of the tubes for obtaining a current of air through the tubes. He stated the following conclusions:

1. A minimum of power is required, when the experimental chamber, whose the velocity of the air is measured (cylindrical section 0.30 m in diameter, 0.24 m in length), is mounted at the air inlet to a truncated cone having an angle of 30 deg., and at the other end is connected to a truncated cone having an angle of 7 deg. 10 min. Better results are obtained if the experiments are made in the open air rather than in a room.

2. The power required to still further reduce if the truncated cone at an angle of 7 deg. is extended beyond the fan, as shown in Fig. 2, all other dimensions of the tube being the same as in Fig. 1. By using this arrangement the velocity of the air at the outlet of the tube is less than before, consequently the loss

of energy is less. It was also noted that in this case better results could be obtained by maintaining the experiment in the open air and not in a closed room, therefore all the other experiments were also made in the open.

3. A third series of experiments was made with three tubes at the diameters shown in Figs. 1, 2, 3, and 4. The angles of the cone of these tubes were the same as in case 1 (7 deg. and 30 deg. respectively). Figs. 4 and 5 show an arrangement by which the two cones, instead of being connected to a cylindrical chamber of the same diameter as the small end of the cones (as in Fig. 4) the distance between the two cones is only 2.50 m, and

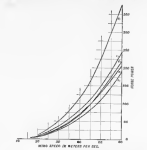


FIG. 5

in Fig. 5 the distance is about 8.50 m. All the other diameters are the same as in Fig. 3.

The results of the tests proved that the power required for producing a current of air at the same velocity in the cylindrical section was least in the tube shown in Fig. 5, was greater in the tube shown in Fig. 4, and still greater as the cone shown in Fig. 1. The results of these tests are indicated in Fig. 6. The curves 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000.

The experiments made by Captain Coatsworth clearly give rise to some well-defined principles governing the best design of a tunnel. At the same time they all proved the advantage of conducting the experiments in the open air, or at least in a very large room. In order to avoid this inconvenience, Colonel Coatsworth suggested the idea of a closed type of tunnel with a continuous circulation of air. Besides utilizing the disadvantage of a large mass as required for obtaining the best efficiency with Captain Coatsworth's type of tunnel, the closed type utilizes the energy possessed by the air at its outlet (which is obviously lost when the discharge takes place in the open air), and furthermore, shows a possible means of the temperature and humidity of the air circulated in the tube.

With a view of obtaining the best design of such a tunnel, the following experiments were made:

Tunnel with Two Cones Closed at Air
In the model experimented upon by Colonel Coatsworth, the central portion of the air stream was designed according to

the indications resulting from experiments made by Captain G. C. as the pressure measurements, the influence of the length and the diameter of the observation chamber (cylindrical portion of the control air duct), the influence of extending it and widening the return section beyond the propeller, and the influence of the section given to the air duct for the return of the air to the inlet (square or circular section), were thoroughly investigated. In all cases the angles of the two cones were 7 deg. and 30 deg., respectively, at the entrance and at the outlet of the observation chamber.

Fig. 7 gives the chief dimensions of the control duct where the fan for sucking the air is mounted at the end of the 7 deg. cone. The cylindrical chamber, having the dimensions shown, is connected directly to the air duct for the return of the air

The experiment was made with the door of the cylindrical chamber closed.

The experimental results of these are obtained in Fig. 13, where curves a, b, c, d correspond to the conditions shown in Figs. 7, 8, 9 and 10, respectively; curves e and f correspond to the conditions shown in Fig. 11 (same closed and open), and curve g corresponds to the conditions shown in Fig. 12.

Conclusions

(1) A decrease in the length of the cylindrical tube, as shown in Fig. 11, gives rise to an increase of power required from the fan as compared with that required for the tunnel shown in Fig. 16. The power needed is even greater if

$N_1 = \text{r.p.m. of fan used for model tunnel for wind speed}$
 $= F_{10}$

$N = \text{r.p.m. of fan used for full size tunnel for wind speed}$
 $= F_0$

$HP_1 = \text{horsepower required for model tunnel for a wind speed } F_{10}$

$HP = \text{horsepower required for full size tunnel for a wind speed } F_0$

$$a = \frac{D}{d}$$

$$F = F_0 \times \sqrt{a}$$

$$N = N_1 \times \sqrt{a}$$

$$HP = HP_1 \times a^2 \times \sqrt{a}$$

The chief dimensions adopted for the Aerodynamic Tunnel

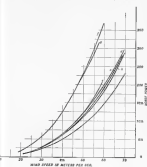


FIG. 13

both in the Instituto Centrale Aeronautico, Rome, after the experiments described above, are given in Fig. 14.

The air is admitted through the square section a, which is joined to the base c of the truncated cone, by means of b. The air is admitted through d in the experimental chamber f. This air is conducted at g to the truncated cone h, to the end of which the fan is installed. The conduct for the return of the air is rectangular in section and is joined to the entrance p and to the outlet s of the main tunnel.

The fan used is a propeller with aerodynamic wooden blades. The vanes adopted after numerous experiments had been made on several small size models, in order to determine the most efficient design. The efficiency of the fan used is 0.75. It is driven by an A. C. 210 hp, 220-volt, three-phase motor making 940 r.p.m. The current for the motor is supplied by a D. C. generator, 145 kw., 110/500 volts, 600 r.p.m.

The power required for corresponding velocities of the air in the experimental chamber is given in the following table:

In the right-hand column the ratio $\frac{F_0}{F_1}$, where $F_0 = \text{thrust}$

required on the fan shaft and $F_1 = \text{thrust of the air in the experimental chamber.}$

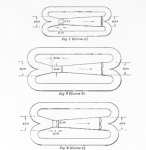


Fig. 7 (thrust a)

Fig. 8 (thrust b)

Fig. 9 (thrust c)

Fig. 10 (thrust d)

These ducts are rectangular in section as far as the extremities of the cones.

Fig. 8 is similar to Fig. 7, except that the cylindrical section of the control duct is longer, and the return duct, being square in section, gradually assumes a circular section like that of the cones.

Fig. 9 is similar to Fig. 8, except that the length of the cylindrical section is the same as in Fig. 7.

Fig. 10 gives the chief dimensions of the control duct where the two cones at the ends are connected to two tubes of the lengths shown. These tubes gradually change from a circular section at their junction with the cone to a rectangular section at their junction with the air duct for the return of the air, these latter being rectangular in section.

Fig. 11 is similar to Fig. 10, except that the cylindrical section of the main duct is continued into a larger concentric cylinder, closed at the ends, of the length shown and having an outlet cone at the curved surface. The square cylindrical tube is interrupted in the center for a length of 0.60 m., thus allowing a communication with the inside of the outer cylinder. When the door of the larger cylinder is open, the main tube is in communication with the outer one, and when the door is closed the inside tube is in communication with the inside of the larger cylinder. The door is closed at the smaller end of the truncated cone and is connected to the outer cylinder side. Curve e, shown in Fig. 13, indicates the conditions that exist when the door is closed; curve f indicates existing conditions when the door open.

Fig. 12 is similar to Fig. 11, except that the smaller tube connects to the larger cylinder when the door is moved, leaving only a short round ring at the smaller end of the truncated cone

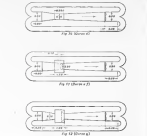


Fig. 11 (thrust e)

Fig. 12 (thrust f)

Fig. 12 (thrust g)

the door to the outside cylinder is left open. The power demand increases still further if the smaller inside tube is left not altogether.

(2) The form of the section of the air ducts for the return of the air has also a slight influence on the power demand, being a little less if the section is circular instead of rectangular.

From the analysis of all these experiments, the type of tunnel which was finally adopted for the Instituto Centrale Aeronautico in Rome was the one shown in Fig. 16.

The advantages which might have been obtained by making the ducts for the return of the air of a circular section instead of rectangular were so slight that they were not considered, for constructive reasons.

The arrangement shown in Fig. 12 would have been a very convenient one, presenting all the advantages of a good model room for containing the model or parts to be experimented upon. However, it was not adopted because it proved to be the least efficient arrangement for carrying out experiments if the room was not airtight (see curves e and f). Considering the dependence of the atmosphere in the room at a high wind speed, such a type of construction would have required a particularly strong and airtight structure, and would not have been so effective, from a mechanical point of view, as the arrangement shown in Fig. 16 (see curve d), which was finally adopted for meeting all these requirements.

The data relative to a full size tunnel having a given diameter in the observation chamber (represented by D), as compared to the corresponding diameter of the model experimental chamber (represented by d), can be calculated according to the following formulas:

$F_0 = \text{wind speed in observation chamber of model tunnel.}$

$F = \text{wind speed in observation chamber of full size tunnel.}$

Velocity of the air in meter per sec.	R.p.m. of the fan	Horsepower required	$\frac{F_0}{F_1}$
100	300	10	1.00
200	600	40	0.50
300	900	90	0.33

The air collector (b and d) is made of wood, and the angle of the cone is 30 deg.

The experimental chamber f is made in two sections, one section adjacent to the collector (2 m. dia. by 1 m. long) made



FIG. 14

of wood, the other section (2 m. dia. by 3 m. long) made of aluminum, with doors on the sides for the admission of models and parts to be experimented upon. These two sections are supported by a cellular aluminum made of thin sheet metal, which compels the air to pass through a large number of coils 5 cm. square by 30 cm. long, having their axis parallel to the axis of the tunnel. This is done in order to obtain a possible flow of the air currents meeting the experimental chamber.

The diffuser has the form of a truncated cone of 7 deg. B



FIG. 15

is made up of cones, which is pointed to render it impervious to the air, and it is held in place by means of a convenient iron structure.

The two doors for the return of the air are made of cement and are rectangular in section, 1.53 m. by 3.50 m. Both the collector and the experimental chamber are located in a room having skylight doors communicating with the outside. The room is lighted by a skylight, and it is here that the measurements and observations are located.

The advantages offered by Crocco's type of tunnel with a closed circuit for the circulation of the air are the chiefly (a)

already pointed out in the elimination of the influence of the surrounding walls of the room in which the tunnel is installed, unless a very large room is used for this purpose, it would be the case with an airship tunnel. In this case the air in the room would be practically still and the influence of the walls would be negligible, an amount of their comparatively great distance from the entrance and the outlet of the tunnel. This eliminates the losses of power resulting from the impact of the air against the walls of the room in which the tunnel is installed, thus losses increasing in magnitude as the dimensions of the room decrease.

Tunnel with One Dart Only for the Return of the Air

Tunnels having only one dart for the return of the air in the chamber where the experiments are made have given very poor results.

In the Aerodynamical Institute at Göttingen, in 1909, there was a tunnel having a cross section of 2 sq. m., the area of



Fig. 16

the tunnel forming a rectangle, in which the maximum wind speed obtained was 30 m. per sec. At first this tunnel led to some very poor measurements of the air velocity at different points of the tunnel cross section.

Professor Prandtl experimented all kinds of difficulties in attempting to measure the air velocity at different points of the tunnel cross section. For the maximum velocity only, at the center of the tunnel, by averaging the air velocity over a length at several points of the cross section. Fig. 15 gives a diagram of the air velocity at different points of the cross section where the experiments were made before and after corrections, and for a wind velocity of only 10 m. per sec.

In 1907, Colonel Crocco built a tunnel at the Laboratory Brignas, Spiez, which had a cross section of 2 sq. m., and a length of 22 m. (see Fig. 16). This tunnel presented the same difficulties as the one at Göttingen, and had to be abandoned.

New York-Toronto Airplane Race

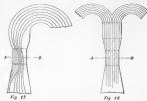
An international airplane race and handicap contest will be run on Aug. 25 by the Aero Club of Canada and the Aero Club of Canada under the rules and regulations promulgated by the American Flying Club, with pilots and airplanes furnished by the U. S. Joint Army and Navy Board of Aeronautics. The contestants are to start simultaneously from New York and Toronto over a round trip course with compulsory control and inspection stops both ways at designated flying fields located at Albany, New York, and the Falls, N. Y. The total distance to be covered is approximately 1,040 miles, with distances between control stops approximately as follows: New York-Albany, 140 miles; Albany-Toronto, 114 miles; Toronto-Buffalo, 140 miles; Buffalo-Toronto, 60 miles.

The object of the contest is to promote the science and sport of aviation in a manner reflecting its safety, permanency and reliability, and is open to all approved types of airplanes carrying airplanes of either fixed or biplane type. Contestants will compete for a cash prize of \$10,000, offered by John McK. Browne, president of the United States, which is divided into two handicap prizes totaling \$7,500 and into three speed prizes totaling \$2,500. In addition there are also offered for competition by contestants, which comprising for the Hatzel Commodore prize, the Canadian Exhibition Trophy, the Aero Club of Canada Trophy and the American Flying Trophy.

Competition for prize will be open to members of the American Flying Club and all affiliated clubs, and the Aero Club of Canada who hold motor and hydro-airplane licenses issued by the U. S. Joint Army and Navy Board of Aeronautics.

dead after a few years of unsuccessful attempts to make it work properly.

In all cases, when one single dart is used instead of two for the return of the air in the tunnel, the influence of the surrounding walls of the room, either the influence of the centrifugal force of the air and the walls of the tunnel, given rise to the formation of air filaments which follow a stream path in the air stream, as shown in Fig. 17. The position of the re-entrant vein A-B, where the air has a maximum velocity, varies according to the speed of the fan.



When, instead of one dart, two symmetrical darts are used for the return of the air, the prevailing conditions of the air flow are like those shown in Fig. 18, and an almost perfect equalization of the air velocity is obtained at every point of the cross section of the tunnel.

These two points have been verified by Colonel Crocco, with experiments made in the old tunnel at the Laboratory of the Physics, Spiez, and in the new tunnel at the Institute Centrale Aeronautica in Rome, Italy.

Experiments, and prior's certificates issued by the Aero Club of Canada. The entry fee is \$25 per airplane, entries will be received up to midnight of Aug. 15, 1919. Entry forms and a set of rules and regulations governing the contest may be had upon application at the American Flying Club, 15 East 58th Street, New York.

The award of the handicap prize will be determined by the following formula, expressing efficiency and reliability in aviation performance:

$$\text{Total Index} = \text{Distance of Prescribed Course} \times \text{Index Factor} \\ = \text{Efficiency} \times \text{Reliability}$$

The index factor will be calculated from the apparent best performance among the entries, and each other machine will be handicapped therefore, in order to make each airplane's performance equally equal. The winner of the handicap prize will be the entrant who shows in order of merit the same most reliable performance under the given rules and regulations.

The Hatzel Commodore speed prize and the three trophies will be awarded in order of merit to the contestants making the round trip course in the shortest total flying time. The Canadian National Exhibition Trophy will be awarded upon the basis of the shortest flying time made by any contestant over the round trip course; the Aero Club of Canada and American Flying Club trophies will be awarded by the American and Canadian entrants, respectively, making the best time either way between Mitchell Field, L. I., and Toronto, Toronto, Ont.

Course in Aerodynamics and Airplane Design

Part III.—Experimental Aeronautical Engineering

By Alexander Klemin

Technical Editor, *Aircraft and Aeronautical Engineering*; Consulting Engineer, *Aerial Mail Service*; Consulting Aeronautical Engineer

Section 7. Climb and Speed-at-Altitude Tests

Climb and Speed-at-Altitude Tests

After the air speed indicator has been calibrated the climb and speed-at-altitude tests may be conducted.

True air speed.—While it is easily possible for almost any pilot to obtain the maximum speed of the airplane at any given altitude, it is a matter of considerable skill to get the most possible climb out of a machine. At ground level, at various of the maximum required and maximum available air speeds, it will be found that there is some one speed at which the engine horsepower is a maximum. This is, of course, the best climbing speed at ground level. It is found in practice, although not always true theoretically, that if the air speed under reading is maintained equal to that which gives the best climb at ground level, the best rate of climb will be obtained. A few preliminary try-out climbs are recommended to determine the air speed reading.

Instruments required.—The instruments required in the two methods for the climb and speed-at-altitude tests are as follows:

Pilot's cockpit:

- (a) Revolution counter.
- (b) Altimeter. This should be set to correspond with barometric pressure on the ground, and not to zero.
- (c) Barometric thermometer, so that heating of the meter may be checked.
- (d) Direct reading air speed indicator. This is not required to take observations but to enable the pilot to check his climbing speed.
- (e) If possible, a maximum climb indicator.
- (f) Observer's cockpit:
- (a) Direct reading of revolution counter.
- (b) Direct reading or recording altimeter. This should be set to correspond with barometric pressure on the ground, and not to zero.
- (c) Direct reading or recording air speed indicator.
- (d) Direct reading or recording climb indicator.
- (e) Stop watch.

Some thought should be given to the selection of the barograph. The scale of this instrument should be appropriate to the climb underlines and the time scale also should be suitable.

carefully extended. The first thermometer should be placed in a position where it will not be affected by the exhaust gases, and if not set according to the instrument book it should be sufficiently large so that it can easily be read from the pilot's or observer's seats.

Procedure in Climb and Speed at Altitude Tests.—A well-defined procedure should be followed in making these tests. When recording type instruments are used, the only difficulty to be anticipated is in the synchronization of the instruments described in the foregoing paragraph.

Where direct reading instruments are used the observer has a rather difficult task. At every 1000 ft., as shown by the altimeter, he must make his point of report. The time taken to start, the start thermometer, the air speed reading, and the r.p.m. of the engine. When the pilot has reached the ceiling, which he determines by the rate of climb becoming so small as to be imperceptible, he gives the climb a straight flight at full throttle, then dives in a lower altitude and at the altitude chooses a straight flight at maximum speed. During the climb, the observer again notes down the air speed, the engine speed and the climb thermometer. The flight at altitude is repeated at various levels. It is very important in this work that the straight flight be of sufficient duration to enable correct readings to be taken.

Typical Climb and Speed Tests

Climb.—In order clearly to illustrate the methods followed, a typical test run will be followed through very carefully. This test was run with a plane fitted with a Liberty 12 engine and described previously. The observer's report for this test is given in table I. The reduction of the results is based on the method described by Capt. H. T. Turner in *The Aeronautical Engineer* and a result is the standard density at altitude employed by the British.

The reduction of results requires some care. These corrections are summarized in table II. In columns 1, 2, 3, 4 and 5 are tabulated the observations made on the test, after making corrections for instrumental errors from calibration curves, such as the calibration curve for the air speed meter. In column 6 are tabulated the pressure corresponding to altitude readings.

TABLE I
Observer's Report

Date: May 24, 1929.		Location: DCA—P. H.		Altitude: as ground (1040 ft.).		Pressure: as ground (29.9 in. mercury).		Time: 10:00 a.m.	
Observer: Alexander Klemin		Observer: Alexander Klemin		Observer: Alexander Klemin		Observer: Alexander Klemin		Observer: Alexander Klemin	
Altitude	Time	Pressure	Altitude	Time	Pressure	Altitude	Time	Pressure	Altitude
0	10:00	29.9	0	10:00	29.9	0	10:00	29.9	0
100	10:01	29.8	100	10:01	29.8	100	10:01	29.8	100
200	10:02	29.7	200	10:02	29.7	200	10:02	29.7	200
300	10:03	29.6	300	10:03	29.6	300	10:03	29.6	300
400	10:04	29.5	400	10:04	29.5	400	10:04	29.5	400
500	10:05	29.4	500	10:05	29.4	500	10:05	29.4	500
600	10:06	29.3	600	10:06	29.3	600	10:06	29.3	600
700	10:07	29.2	700	10:07	29.2	700	10:07	29.2	700
800	10:08	29.1	800	10:08	29.1	800	10:08	29.1	800
900	10:09	29.0	900	10:09	29.0	900	10:09	29.0	900
1000	10:10	28.9	1000	10:10	28.9	1000	10:10	28.9	1000
1100	10:11	28.8	1100	10:11	28.8	1100	10:11	28.8	1100
1200	10:12	28.7	1200	10:12	28.7	1200	10:12	28.7	1200
1300	10:13	28.6	1300	10:13	28.6	1300	10:13	28.6	1300
1400	10:14	28.5	1400	10:14	28.5	1400	10:14	28.5	1400
1500	10:15	28.4	1500	10:15	28.4	1500	10:15	28.4	1500
1600	10:16	28.3	1600	10:16	28.3	1600	10:16	28.3	1600
1700	10:17	28.2	1700	10:17	28.2	1700	10:17	28.2	1700
1800	10:18	28.1	1800	10:18	28.1	1800	10:18	28.1	1800
1900	10:19	28.0	1900	10:19	28.0	1900	10:19	28.0	1900
2000	10:20	27.9	2000	10:20	27.9	2000	10:20	27.9	2000

TABLE II

RESULTS OF DATA—CLIMBER TEST

Observed climb height	Time	Corresponding rate of ascent	Temperature at 1000 ft.	Density	Corrected rate of climb	Correct rate of climb	Observed rate of climb	R.P.M.
1,000	0:20.0	5000	59.0	0.00120	5000	5000	5000	1,000
1,500	0:25.0	6000	58.0	0.00118	6000	6000	6000	1,200
2,000	0:30.0	7000	57.0	0.00116	7000	7000	7000	1,400
2,500	0:35.0	8000	56.0	0.00114	8000	8000	8000	1,600
3,000	0:40.0	9000	55.0	0.00112	9000	9000	9000	1,800
3,500	0:45.0	10,000	54.0	0.00110	10,000	10,000	10,000	2,000
4,000	0:50.0	11,000	53.0	0.00108	11,000	11,000	11,000	2,200
4,500	0:55.0	12,000	52.0	0.00106	12,000	12,000	12,000	2,400
5,000	1:00.0	13,000	51.0	0.00104	13,000	13,000	13,000	2,600
5,500	1:05.0	14,000	50.0	0.00102	14,000	14,000	14,000	2,800
6,000	1:10.0	15,000	49.0	0.00100	15,000	15,000	15,000	3,000
6,500	1:15.0	16,000	48.0	0.00098	16,000	16,000	16,000	3,200
7,000	1:20.0	17,000	47.0	0.00096	17,000	17,000	17,000	3,400
7,500	1:25.0	18,000	46.0	0.00094	18,000	18,000	18,000	3,600
8,000	1:30.0	19,000	45.0	0.00092	19,000	19,000	19,000	3,800
8,500	1:35.0	20,000	44.0	0.00090	20,000	20,000	20,000	4,000
9,000	1:40.0	21,000	43.0	0.00088	21,000	21,000	21,000	4,200
9,500	1:45.0	22,000	42.0	0.00086	22,000	22,000	22,000	4,400
10,000	1:50.0	23,000	41.0	0.00084	23,000	23,000	23,000	4,600
10,500	1:55.0	24,000	40.0	0.00082	24,000	24,000	24,000	4,800
11,000	2:00.0	25,000	39.0	0.00080	25,000	25,000	25,000	5,000
11,500	2:05.0	26,000	38.0	0.00078	26,000	26,000	26,000	5,200
12,000	2:10.0	27,000	37.0	0.00076	27,000	27,000	27,000	5,400
12,500	2:15.0	28,000	36.0	0.00074	28,000	28,000	28,000	5,600
13,000	2:20.0	29,000	35.0	0.00072	29,000	29,000	29,000	5,800
13,500	2:25.0	30,000	34.0	0.00070	30,000	30,000	30,000	6,000
14,000	2:30.0	31,000	33.0	0.00068	31,000	31,000	31,000	6,200
14,500	2:35.0	32,000	32.0	0.00066	32,000	32,000	32,000	6,400
15,000	2:40.0	33,000	31.0	0.00064	33,000	33,000	33,000	6,600
15,500	2:45.0	34,000	30.0	0.00062	34,000	34,000	34,000	6,800
16,000	2:50.0	35,000	29.0	0.00060	35,000	35,000	35,000	7,000
16,500	2:55.0	36,000	28.0	0.00058	36,000	36,000	36,000	7,200
17,000	3:00.0	37,000	27.0	0.00056	37,000	37,000	37,000	7,400
17,500	3:05.0	38,000	26.0	0.00054	38,000	38,000	38,000	7,600
18,000	3:10.0	39,000	25.0	0.00052	39,000	39,000	39,000	7,800
18,500	3:15.0	40,000	24.0	0.00050	40,000	40,000	40,000	8,000
19,000	3:20.0	41,000	23.0	0.00048	41,000	41,000	41,000	8,200
19,500	3:25.0	42,000	22.0	0.00046	42,000	42,000	42,000	8,400
20,000	3:30.0	43,000	21.0	0.00044	43,000	43,000	43,000	8,600
20,500	3:35.0	44,000	20.0	0.00042	44,000	44,000	44,000	8,800
21,000	3:40.0	45,000	19.0	0.00040	45,000	45,000	45,000	9,000
21,500	3:45.0	46,000	18.0	0.00038	46,000	46,000	46,000	9,200
22,000	3:50.0	47,000	17.0	0.00036	47,000	47,000	47,000	9,400
22,500	3:55.0	48,000	16.0	0.00034	48,000	48,000	48,000	9,600
23,000	4:00.0	49,000	15.0	0.00032	49,000	49,000	49,000	9,800
23,500	4:05.0	50,000	14.0	0.00030	50,000	50,000	50,000	10,000

In column 3 is tabulated the rate of density in standard air at 35 deg. Cent. and 300 m.m. of mercury. In column 4 are given the standard heights corresponding to these values of density. To obtain the second rate of climb given in column 7 an auxiliary curve is required. In Fig. 1 the observed climbs are plotted without correction against the rate of climb. Then at any altitude the second rate of climb is obtained from the slope of the tangent to the curve, and is quite reliable from this figure.

Column 8 gives the second rate of climb corrected for the temperature. This correction is obtained by the formula:

$$R = \frac{273 + t}{273 + 35} \times k$$

where t is the temperature in deg. Cent. at the point under consideration.

The corrected rates of climb are now plotted against the standard heights given in column 5, as shown in Fig. 2. These points should lie almost, if not quite, in a straight line. Through the points a smooth curve is plotted, and from this curve the rate of climb corresponding to the rate of climb of feet in thousands of feet in standard air can be read. Knowing the rate of climb for each 1000 ft., the time of climb to any required height can be computed.

For example, to compute the time of climb to 1,800 ft., the average rate of climb is

$$\frac{1330 + 1875}{2} = 1602 \text{ ft. per min.}$$

The time is therefore

$$\frac{90 \times 1000}{1300} = 69 \text{ sec.}$$

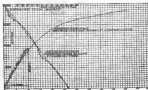


FIG. 1. CORRECTED RATE OF CLIMB PLOTTED AGAINST STANDARD HEIGHTS

To 2000 ft. the average rate of climb is

$$\frac{1370 + 1925}{2} = 1254 \text{ ft. per min.}$$

The time is therefore

$$\frac{90 \times 1000}{1245} = 72 \text{ sec. 30 in.}$$

To 3000 ft. the average rate of climb is

$$\frac{1455 + 2145}{2} = 1350 \text{ ft. per min.}$$

The time is therefore

$$\frac{90 \times 1000}{1185} = 75 \text{ sec. 24 in.}$$

The results of these computations are plotted in Fig. 3. In table III are given the r.p.m. values against standard heights.

It should be noted that the quickest way of obtaining the theoretical ceiling is to produce the rate of climb against standard altitude and the curve intersects the ordinate at the engine. This intersection determines the altitude. Generally the decrease in the rate of climb is proportional to altitude, and the curve can be represented by a straight line. In drawing this curve it has been suggested that more weight should be given to the points above 5000 ft. than below, since above this height the performance is more regular.

Engine ceiling.—This is determined by the point at the point where the rate of climb is less than 100 ft. per min.

Speed at altitude.—After the pilot has climbed to the desired ceiling of the machine and begun the descent, he levels off at different altitudes, as previously explained, and then reads for a full minute at each altitude. It is necessary to fly level



FIG. 2. CURVE OF TIME AND RATE OF CLIMB TO EACH 1000 FT.

TABLE III

RESULTS OF CLIMBER TESTS—STANDARD AIR

Altitude in standard air	Time	Rate of climb	R.P.M.
1,000	0:20.0	5000	1,000
1,500	0:25.0	6000	1,200
2,000	0:30.0	7000	1,400
2,500	0:35.0	8000	1,600
3,000	0:40.0	9000	1,800
3,500	0:45.0	10,000	2,000
4,000	0:50.0	11,000	2,200
4,500	0:55.0	12,000	2,400
5,000	1:00.0	13,000	2,600
5,500	1:05.0	14,000	2,800
6,000	1:10.0	15,000	3,000
6,500	1:15.0	16,000	3,200
7,000	1:20.0	17,000	3,400
7,500	1:25.0	18,000	3,600
8,000	1:30.0	19,000	3,800
8,500	1:35.0	20,000	4,000
9,000	1:40.0	21,000	4,200
9,500	1:45.0	22,000	4,400
10,000	1:50.0	23,000	4,600
10,500	1:55.0	24,000	4,800
11,000	2:00.0	25,000	5,000
11,500	2:05.0	26,000	5,200
12,000	2:10.0	27,000	5,400
12,500	2:15.0	28,000	5,600
13,000	2:20.0	29,000	5,800
13,500	2:25.0	30,000	6,000
14,000	2:30.0	31,000	6,200
14,500	2:35.0	32,000	6,400
15,000	2:40.0	33,000	6,600
15,500	2:45.0	34,000	6,800
16,000	2:50.0	35,000	7,000
16,500	2:55.0	36,000	7,200
17,000	3:00.0	37,000	7,400
17,500	3:05.0	38,000	7,600
18,000	3:10.0	39,000	7,800
18,500	3:15.0	40,000	8,000
19,000	3:20.0	41,000	8,200
19,500	3:25.0	42,000	8,400
20,000	3:30.0	43,000	8,600
20,500	3:35.0	44,000	8,800
21,000	3:40.0	45,000	9,000
21,500	3:45.0	46,000	9,200
22,000	3:50.0	47,000	9,400
22,500	3:55.0	48,000	9,600
23,000	4:00.0	49,000	9,800
23,500	4:05.0	50,000	10,000

by multiplying it by the square root of the ratio of density in standard air, as shown in Figs. 1 and 2.

In column 8 is recorded the speed of the engine at each altitude, after correcting in accordance with the calculation of the tailstream.

Example.—Take the computations for the speed at 2000 ft. The pressure corresponding to the second height of 2000 ft. is found as reference to be 26.83 in. mercury. With this pressure and a temperature of 58 deg. Cent., the rate of density in standard density is found to be equal to 0.935. This relative density gives a height of 2000 ft. on the curve of standard heights. The corrected air speed therefore is

$$\frac{120}{\sqrt{0.935}} = 127 \text{ m.p.h.}$$

The corrected air speeds and engine revolutions are plotted in cross curves against standard altitudes. Through the plotted points smooth curves are drawn, and from these curves the air speed and engine rpm corresponding to the 2000 ft.

TABLE IV
RESULTS OF CLIMBER TESTS—STANDARD AIR

Observed altitude	Corresponding rate of climb in standard air	Best temperature deg. Cent.	Relative density	Corrected altitude	Air speed engine revolving	Corresponding speed	R.P.M.
1,000	5000	59.0	0.935	1,000	120	127.8	1,200
1,500	6000	58.0	0.930	1,500	140	149.2	1,400
2,000	7000	57.0	0.925	2,000	160	170.6	1,600
2,500	8000	56.0	0.920	2,500	180	192.0	1,800
3,000	9000	55.0	0.915	3,000	200	213.4	2,000
3,500	10,000	54.0	0.910	3,500	220	234.8	2,200
4,000	11,000	53.0	0.905	4,000	240	256.2	2,400
4,500	12,000	52.0	0.900	4,500	260	277.6	2,600
5,000	13,000	51.0	0.895	5,000	280	299.0	2,800
5,500	14,000	50.0	0.890	5,500	300	320.4	3,000
6,000	15,000	49.0	0.885	6,000	320	341.8	3,200
6,500	16,000	48.0	0.880	6,500	340	363.2	3,400
7,000	17,000	47.0	0.875	7,000	360	384.6	3,600
7,500	18,000	46.0	0.870	7,500	380	406.0	3,800
8,000	19,000	45.0	0.865	8,000	400	427.4	4,000
8,500	20,000	44.0	0.860	8,500	420	448.8	4,200
9,000	21,000	43.0	0.855	9,000	440	470.2	4,400
9,500	22,000	42.0	0.850	9,500	460	491.6	4,600
10,000	23,000	41.0	0.845	10,000	480	513.0	4,800
10,500	24,000	40.0	0.840	10,500	500	534.4	5,000
11,000	25,000	39.0	0.835	11,000	520	555.8	5,200
11,500	26,000	38.0	0.830	11,500	540	577.2	5,400
12,000	27,000	37.0	0.825	12,000	560	598.6	5,600
12,500	28,000	36.0	0.820	12,500	580	620.0	5,800
13,000	29,000	35.0	0.815	13,000	600	641.4	6,000
13,500	30,000	34.0	0.810	13,500	620	662.8	6,200
14,000	31,000	33.0	0.805	14,000	640	684.2	6,400
14,500	32,000	32.0	0.800	14,500	660	705.6	6,600
15,000	33,000	31.0	0.795	15,000	680	727.0	6,800
15,500	34,000	30.0	0.790	15,500	700	748.4	7,000
16,000	35,000	29.0	0.785	16,000	720	769.8	7,200
16,500	36,000	28.0	0.780	16,500	740	791.2	7,400
17,000	37,000	27.0	0.775	17,000	760	812.6	7,600
17,500	38,000	26.0	0.770	17,500	780	834.0	7,800
18,000	39,000	25.0	0.765	18,000	800	855.4	8,000
18,500	40,000	24.0	0.760	18,500	820	876.8	8,200
19,000	41,000	23.0	0.755	19,000	840	898.2	8,400
19,500	42,000	22.0	0.750	19,500	860	919.6	8,600
20,000	43,000	21.0	0.745	20,000	880	941.0	8,800
20,500	44,000	20.0	0.740	20,500	900	962.4	9,000
21,000	45,000	19.0	0.735	21,000	920	983.8	9,200
21,500	46,000	18.0	0.730	21,500	940	1005.2	9,400
22,000	47,000	17.0	0.725	22,000	960	1026.6	9,600
22,500	48,000	16.0	0.720	22,500	980	1048.0	9,800
23,000	49,000	15.0	0.715	23,000	1,000	1069.4	10,000
23,500	50,000	14.0	0.710	23,500	1,020	1090.8	10,200
24,000	51,000	13.0	0.705	24,000	1,040	1112.2	10,400
24,500	52,000	12.0	0.700	24,500	1,060	1133.6	10,600
25,000	53,000	11.0	0.695	25,000	1,080	1155.0	10,800
25,500	54,000	10.0	0.690	25,500	1,100	1176.4	11,000
26,000	55,000	9.0	0.685	26,000	1,120	1197.8	11,200
26,500	56,000	8.0	0.680	26,500	1,140	1219.2	11,400
27,000	57,000	7.0	0.675	27,000	1,160	1240.6	11,600
27,500	58,000	6.0	0.670	27,500	1,180	1262.0	11,800
28,000	59,000	5.0	0.665	28,000	1,200	1283.4	12,000
28,500	60,000	4.0	0.660	28,500	1,220	1304.8	12,200
29,000	61,000	3.0	0.655	29,000	1,240	1326.2	12,400
29,500	62,000	2.0	0.650	29,500	1,260	1347.6	12,600
30,000	63,000	1.0	0.645	30,000	1,280	1369.0	12,800
30,500	64,000	0.0	0.640	30,500	1,300	1390.4	13,000
31,000	65,000	-1.0	0.635	31,000	1,320	1411.8	13,200
31,500	66,000	-2.0	0.630	31,500	1,340	1433.2	13,400
32,000	67,000	-3.0	0.625	32,000	1,360	1454.6	13,600
32,500	68,000	-4.0	0.620	32,500	1,380	1476.0	13,800
33,000	69,000	-5.0	0.615	33,000	1,400	1497.4	14,000
33,500	70,000	-6.0	0.610	33,500	1,420	1518.8	14,200
34,000	71,000	-7.0	0.605	34,000	1,440	1540.2	14,400
34,500	72,000	-8.0	0.600	34,500	1,460	1561.6	14,600
35,000	73,000	-9.0	0.595	35,000	1,480	1583.0	14,800
35,500	74,000	-10.0	0.590	35,500	1,500	1604.4	15,000
36,000	75,000	-11.0	0.585	36,000	1,520	1625.8	15,200
36,500	76,000	-12.0	0.580	36,500	1,540	1647.2	15,400
37,000	77,000	-13.0	0.575	37,000	1,560	1668.6	15,600
37,500	78,000	-14.0	0.570	37,500	1,580	1690.0	15,800
38,000	79,000	-15.0	0.565	38,000	1,600	1711.4	16,000
38,500	80,000	-16.0	0.560	38,500	1,620	1732.8	16,200
39,000	81,000	-17.0	0.555	39,000	1,640	1754.2	16,400
39,500	82,000	-18.0	0.550	39,500	1,660	1775.6	16,600
40,000	83,000	-19.0	0.545	40,000	1,680	1797.0	16,800
40,500	84,000	-20.0	0.540	40,500	1,700	1818.4	17,000
41,000	85,000	-21.0	0.535	41,000	1,720	1839.8	17,200
41,500	86,000	-22.0	0.530	41,500	1,740	1861.2	17,400
42,000	87,000	-23.0	0.525	42,000	1,760	1882.6	17,600
42,500	88,000	-24.0	0.520	42,500	1,780	1904.0	17,800
43,000	89,000	-25.0	0.515	43,000	1,800	1925.4	18,000
43,500	90,000	-26.0	0.510	43,500	1,820	1946.8	18,200
44,000	91,000	-27.0	0.505	44,000	1,840	1968.2	18,400
44,500	92,000	-28.0	0.500	44,500	1,860	1989.6	18,600
45,000	93,000	-29.0	0.495	45,000	1,880	2011.0	18,800
45,500	94,000	-30.0	0.490	45,500	1,900	2032.4	19,000
46,000	95,000	-31.0	0.485	46,000	1,920	2053.8	19,200
46,500	96,000	-32.0	0.480	46,500	1,940	2075.2	19,400
47,000	97,000	-33.0	0.475	47,000	1,960	2096.6	19,600
47,500	98,000	-34.0	0.470	47,500	1,980	2118.0	19,800
48,000	99,000	-35.0	0.465	48,000	2,000	2139.4	20,000
48,500	100,000	-36.0	0.460	48,500	2,020	2160.8	20,200
49,000	101,000	-37.0	0.455	49,000	2,040	2182.2	20,400
49,500	102,000	-38.0	0.450	49,500	2,060	2203.6	20,600
50,000	103,000	-39.0	0.445	50,000	2,080	2225.0	20,800
50,500	104,000	-40.0	0.440	50,500	2,100	2246.4	21,000
51,000	105,000	-41.0	0.435	51,000	2,120	2267.8	21,200
51,500	106,000	-42.0	0.430	51,500	2,140	2289.2	21,400
52,000	107,000	-43.0	0.425	52,000	2,160	2310.6	21,600
52,500	108,000	-44.0	0.420	52,500	2,180	2332.0	21,800
53,000	109,000	-45.0	0.415	53,000	2,200	2353.4	22,000
53,500	110,000	-46.0	0.410	53,500	2,220	2374.8	22,200
54,000	111,000	-47.0	0.405	54,000	2,240	2396.2	22,400
54,500	112,000	-48.0	0.400	54,500	2,260	2417.6	22,600
55,000	113,000	-49.0	0.395	55,000	2,280	2439.0	22,800
55,500	114,000	-50.0	0.390	55,500	2,300	2460.4	23,000
56,000	115,000	-51.0	0.385	56,000	2,320	2481.8	23,200
56,500	116,000	-52.0	0.380	56,500	2,340	2503.2	23,400
57,000	117,000	-53.0	0.375	57,000	2,360	2524.6	23,600
57,500	118,000	-54.0	0.370	57,500	2,380	2546.0	23,800
58,000	119,000	-55.0	0.365	58,000	2,400	2567.4	24,000
58,500	120,000	-56.0	0.360	58,500	2,420	2588.8	24,200
59,000	121,000	-57.0	0.355	59,000	2,440	2610.2	24,400
59,500	122,000	-58.0	0.350	59,500	2,460	2631.6	24,600
60,000	123,000	-59.0	0.345	60,000	2,480	2653.0	24,800
60,500	124,000	-60.0	0.340	60,500	2,500	2674.4	25,000
61,000	125,000	-61.0	0.335	61,000	2,520	2695.8	25,200
61,500	126,000	-62.0	0.330	61,500	2,540	2717.2	25,400
62,000	127,000	-63.0	0.325	62,000	2,560	2738.6	25,600
62,500	128,000	-64.0	0.320	62,500	2,580	2760.0	25,800
63,000	129,000	-65.0	0.315	63,000	2,600	2781.4	26,000
63,500	130,000	-66.0	0.310	63,500	2,620	2802.8	26,200
64,000	131,000	-67.0	0.305	64,000	2,640	2824.2	26,400
64,500	132,000	-68.0	0.300	64,500	2,660	2845.6	26,600
65,000	133,000	-69.0	0.295	65,000	2,680	2867.0	26,800
65,500	134,000	-70.0	0.290	65,500	2,700	2888.4	27,000
66,000	135,000	-71.0	0.285	66,000	2,720	2909.8	27,200
66,500	136,000	-72.0	0.280	66,500	2,740	2931.2	27,400
67,000	137,000	-73.0	0.275	67,000	2,760	2952.6	27,600
67,500	138,000	-74.0	0.270	67,500	2,780	2974.0	27,800
68,000	139,000	-75.0	0.265	68,000	2,800	2995.4	28,000
68,500	140,000	-76.0	0.260	68,500	2,820	3016.8	28,200
69,000	141,000	-77.0	0.255	69,000	2,840	3038.2	28,400
69,500	142,000	-78.0	0.250	69,500	2,860	3059.6	28,600
70,000	143,000	-79.0	0.245	70,000	2,880	3081.0	28,800
70,500	144,000	-80.0	0.240	70,500	2,900	3102.4	29,000
71,000	145,000	-81.0	0.235	71,000	2,920	3123.8	29,200
71,500	146,000	-82.0	0.230	71,500	2,940		

carry about twice the load of solid square struts of the same weight and section.

Building of Hollow Struts

Finally, as will be shown, enhance the apparent superiority of steel over wood as a material for struts. For the solid struts to be based on the assumption that the bending or load resistance or buckling takes place. Such an assumption is, of course, entirely possible with respect to solid struts or even hollow struts having comparatively thick walls, but it is hardly valid for thin-walled columns, such as the steel struts under consideration. A hinged strut at the wall of the strut considered as a "free body" is, in effect, also a small column loaded axially at each end. If we apply to this stry the laws that govern columns, we may expect such a stry to hold very little load. If the wall of the stry is considerably greater than its diameter (and any other maximum stress would hardly be justified in this direction), it is obvious that the least moment of inertia must be low, the moment of resistance about the boundary where the curvature is low. The result of this comparatively low least moment of inertia is that buckling takes place. Tests on plywood and steel struts with relatively thin shells have shown that failure does actually occur at these places midway between the ends of the struts where the bending stresses are high and the curvature of the boundary is low. In order to obtain the best results from steel-strut struts it is necessary, then, to provide some form of reinforcement that will maintain the tendency to buckle.

Shear Strength

Upon loading a strut so that bending takes place, shear stresses are introduced. In the case of hollow struts in which the material along the central axis is in tension or in compression, or low shear strength, these stresses may cause failure of the strut by shear.

The following equation, governing the intensity of longitudinal shear stress in a strut, shows how the shear stress varies with distance along the axis of the strut and at right angles to the axis.

$$s_s = \frac{dM}{dz} \int_{y_1}^{y_2} y dy$$

s_s = Intensity or unit shear stress along a line parallel to the axis of symmetry of the stry, at distance y from the axis of symmetry, and in a direction parallel to the stry length.

$\frac{dM}{dz}$ = Rate at which the external bending moment M changes with respect to distance z along the axis of the stry z = Least moment of inertia of the stry section, b = Breadth of the section distant y from the axis of symmetry.

$\int y dy$ = First moment of the section bounded by a line parallel to the axis of symmetry and distant y from the axis of symmetry, and the stry boundary b being the distance from the axis of symmetry to the outermost fiber.

The elastic curve of a loaded stry of uniform section approximates a sine wave, so that the rate at which the bending moment changes with respect to distance z is greatest at the ends of the stry where the slope of the elastic curve with respect to the straight line connecting the ends of the stry is greatest, and, consequently, the shear stresses are greatest at the ends of the stry.

The maximum value which the intensity for the first moment attains is $s_s = \frac{dM}{dz} \int_{y_1}^{y_2} y dy$, and the maximum value which the intensity for the first moment attains is $s_s = \frac{dM}{dz} \int_{y_1}^{y_2} y dy$.

On the basis of the laws governing the strength of hollow columns, such as struts, airplane struts would seem to follow strains of the same weight and section boundary as solid square struts, and made either of wood having a high modulus of elasticity or of a steel shell, should show very promising results as compared to those struts of wood. It is recommended that in providing to maintain buckling, these struts in such struts are greatest at the ends of the stry in the place of symmetry. Hollow struts are in providing in hollow struts to prevent failure due to shear.

Book Reviews

AIRCRAFT DESIGN AND CONSTRUCTION. By Clarence Pombo. (McGraw-Hill Book Company. 443 pp., 242 illus.)

This book covers a wide range and, being well and correctly written, it will be useful for the student as well as for the specialist in designing aircraft. The book is written in a simple and direct style, and the illustrations are of a high standard. It is a very strong recommendation. Apart from these minor remarks, the presentation is clear and good.

Introductory chapters on the structure of the airplane are followed by some interesting notes on the radiator and engine, and on engine systems. Propeller theory is briefly dealt with. Part II, dealing with the elements of aerodynamics, gives a simple introduction to the subject. It is noted that in the construction of gliding flight and flight with power on the introduction of aerodynamic methods will make an easy subject more difficult than necessary.

A very interesting chapter deals with the possibilities of the airplane as an engine for gliding flight. The chapter is well written and contains a number of interesting facts. There is also a short study of long-range flying. The chapters on engine systems are well written and contain many facts. The chapters on engine systems are well written and contain many facts. The chapters on engine systems are well written and contain many facts.

It is gratifying to see a book which is of real value to the aeronautical field.

AIRCRAFT AND AIRCRAFT ENGINEERING. By Reed Denison. (McGraw-Hill Book Company. 443 pp., 242 illus.)

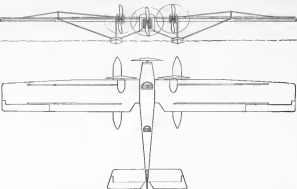
Problems are presented in a clear and simple manner which makes the reader to understand the solution readily while the experienced designer can immediately apply formulas and other data. While the author has no time to discuss the possibility of practical application, the work is mainly concerned with fundamental principles and with actual examples of construction.

Chapter III on thermodynamics, chapter IV and V on the mechanics, and chapters VI to XIII on design are especially good. Each chapter is a complete exposition of the subject under consideration.

The book is divided into the following chapters: 1. The working machine. 2. The laws of gases. 3. The four-stroke cycle. 4. The four-stroke cycle. 5. The engine turning moment. 6. Engine speed variations and flywheel design. 7. The cylinder. 8. The piston, piston rings and valves. 9. The connecting rod. 10. The crankshaft. 11. The crankshaft. 12. The crankshaft. 13. The crankshaft. 14. The crankshaft. 15. The crankshaft. 16. The crankshaft. 17. The crankshaft. 18. The crankshaft. 19. The crankshaft. 20. The crankshaft. 21. The crankshaft. 22. The crankshaft. 23. The crankshaft. 24. The crankshaft. 25. The crankshaft. 26. The crankshaft. 27. The crankshaft. 28. The crankshaft. 29. The crankshaft. 30. The crankshaft. 31. The crankshaft. 32. The crankshaft. 33. The crankshaft. 34. The crankshaft. 35. The crankshaft. 36. The crankshaft. 37. The crankshaft. 38. The crankshaft. 39. The crankshaft. 40. The crankshaft. 41. The crankshaft. 42. The crankshaft. 43. The crankshaft. 44. 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and is generally in sight of land, whereas a flight from California to Hawaii involves a constant distance of over 3000 miles without any land being in sight between start and finish.

The White seaplane is a twin-float monoplane of original design. The most striking feature is the disposition of the power plant, which is made up of a Hispano-Suiza 300 hp. engine installed in the nose of the fuselage and two 160 hp. engines of the same make which are mounted on the wings on either side of the fuselage. All three engines drive



FRONT ELEVATION AND PLAN OF THE WHITE SEAPLANE

linear aircrews. The positioning of the power plant into three engine units, two of which develop a horsepower equivalent to the remaining unit in an interesting attempt to eliminate the drawbacks of mechanical breakdown in multi-engine airplanes, namely the decrease in flight speed and maneuverability when one wing engine fails. As the seaplane has been designed to normally fly with 300 hp., its designed speed then being 150 m.p.h., the chance of a forced landing due to engine failure is greatly lessened. On the trans-Pacific flight it is proposed to start off on the two wing engines, switch them off after a quarter of hour and turn on the central engine, and repeat the performance at given intervals to allow the engines to rest and to be supported. Minor repairs and adjustments, such as touching the oil indicator and oil pressure systems, could therefore be made during the flight.

The fuselage is of monocoque construction, being built up of Duralumin, a stronger substitute of D'Alumin. An Alumin alloy which is oriented together under hydraulic pressure. Two cockpit are provided in the fuselage, the one forward seating two pilots, while the other cockpit affords accommodation to the navigator. The fuselage is strong enough to allow the pilot off watch to stretch himself, for which purpose a special locker is provided. The fuel system is so fitted in the fuselage between the two cockpits. The overall length is 39 ft.

The pontoons, which are spaced 10 ft. apart, extend more than half the length of the fuselage to prevent toppling in a heavy sea. They are built of monocoque and cedar veneer, and are divided into numerous watertight compartments by means of bulkheads, each pontoon has sufficient displacement to support the machine afloat, and the fuselage is watertight. The height of the machine from the pontoon keels to the top of the fuselage is 9 ft.

The monocoque wings have an overall span of 92 ft. and

The meteorological conditions are good, the climate is warm and pleasant, and, though there are many violent storms in the Pacific, they are clearly infrequent in nature, and very long of duration, and, most important of all, while they may be violent and unaccountably frequent, they do not leave the surface of the ocean calm and created for long periods after they have passed away. The calm of the North Atlantic, which during the greater part of the winter is turbulent and stormy.

The geographical conditions are also nearly ideal, for every few hundred miles one is found groups of islands forming sheltered spots where flying craft could take refuge or refill their fuel tanks.

Commercial Aspects

It will be asked, "Is there anything in it?" Though this question is almost impossible to answer, there are strong reasons for thinking that there is. The success of such a service would depend, primarily, upon the amount of transportation to be done, other conditions being comparatively simple. It is better to consider such and passenger ages, and it is likely that such work will be regularly carried by air before passengers.

The weight of mail matter, according to the annual report of the Postmaster-General, carried in vessels and outwards between Great Britain and Australia and New Zealand for the last previous year was approximately 4,000 tons, rather more than half of which was outward from the United Kingdom and rather less than half was inward to the United Kingdom. Suppose, therefore, that Australia could be reached in five or six days either via Africa and the Malay Peninsula, or via U. S. A. and Hawaii, and that the competing routes would share half this available traffic—that is to say, one half of the total traffic would be sent by one route and the other half by the other route—a maximum of about 2,000 tons per week, the total cost and hence, would possibly be available during the year along such route.

One must not assume, however, that the whole of the public who correspond with Australia and New Zealand would suddenly send themselves of the new form of mail service, probably only one half of the public would do so. The service, however, business letters, and newspapers—would at first be limited. Upon this the assumption is made that the mail to Great Britain via U. S. A. would be about 400 tons, while the mail to the several dominions would be about 100 tons per annum.

American-Australian Mail

To this, however, must be added a proportion of the present mail between U. S. A. and the several colonies. Though the exact figures for this are not available, it would appear from a perusal of the Postmaster-General's report to be not much more than that which is now sent by sea. If we add 100 tons of this to the several mails to each dominion, we would have 500 tons from Australia and New Zealand to U. S. A. and 700 tons into the same countries via the Pacific.

This gives a working idea of how much mail matter would have to be carried—about fifteen tons per week from the United States, some ten tons per week to the States. To carry on the safe side, however, we will consider that there are only one ton in each direction. To carry this, three flying boats, capable of carrying three tons, in each direction would be required weekly.

Now the question is: Is it worth it to show whether there would be any quantity of mails to carry; it seems a fair assumption that there would be, and that the service would be profitable. It is necessary to make the service pay, and therefore is required—though, as a matter of interest, an indication of possible future is given later.

The next question to consider is what would be the saving in time. This is shown in some comparative tables given below.

	By Sea	By Air	By Sea	By Air
London-Australia	30 days	4 days	30 days	4 days
London-New Zealand	30 days	4 days	30 days	4 days
London-Panama	10 days	10 days	10 days	10 days
London-San Francisco	10 days	10 days	10 days	10 days
London-Hawaii	10 days	10 days	10 days	10 days
London-San Francisco	10 days	10 days	10 days	10 days
London-Hawaii	10 days	10 days	10 days	10 days
London-San Francisco	10 days	10 days	10 days	10 days
London-Hawaii	10 days	10 days	10 days	10 days
London-San Francisco	10 days	10 days	10 days	10 days
London-Hawaii	10 days	10 days	10 days	10 days

*This is the White Seaplane, and though it may not actually come within the limit of this table, it is intended for comparison.

This table shows plainly that journey "across country" is almost almost certainly a success of the time taken, one is quickly and comfortably carried out in a few hours, or at most in a few days. This fact has a distinct business significance.

Calculations in the question of airplane maintenance and fueling, based upon experience gained in pre-war days and modified by recent experience with seaplanes built since the war, are indicative that the oil in each of a strong boat after the war, as a commercial proposition, should not exceed 100,000 lbs. per mile—this figure including fuel, repairs, crewmen, depreciation, profits, other expenses, and all maintenance charges. This would give the actual cost of flying a machine from Sydney to San Francisco as about £200.

Considering the present state of affairs, we can get a rough approximation of the postal rates necessary to make a profit. Sydney, Brisbane, Melbourne, New California, New Zealand, and Fiji, 1700 or thereabouts, islands between Fiji and Hawaii, 20 or thereabouts, Hawaii and San Francisco, 100 or thereabouts. However, if the payment for letters and parcels between Sydney and San Francisco averaged only 20 or thereabouts, and time taken were carried per trip, the complete per trip would amount to £200.

Passenger Rates

As to passengers, with a maximum of about thirty, say an average number of about twenty, the cost per passenger mile would average about three shillings to a penny a mile. This fare would depend, of course, largely upon the number of passengers, it might reasonably be £20 £30 between Sydney and San Francisco.

Now then we have glanced at the preliminary financial factors, let us now glance at the possibilities resulting from the establishment of such a service.

First, the United States of America would be only some 20 days from Australia, that is, a saving of nearly three weeks on the sea journey. In addition to this, there would be a three time a week service; this would be a point of interest to the business men of U. S. A. and Australia. There are, however, others who would find out the advantage of such a service—namely, those who wish to go to the east coast, south and other groups along or near to the track of the flying boat.

Secondly, the service of the proposed service would be from Sydney to Fiji via Brisbane, Melbourne, the others of the New California group, and New Zealand; thence via Samoa, Manila, Cebu, Hong Kong, Shanghai, and Japan, and thence from Hawaii to San Francisco. The route would be pretty well direct unless a favorable wind is found to exist making a work which is done from the straight path. This question of deviation to obtain favorable winds is one which has yet to be thoroughly investigated, and need not be discussed here.

Rebates

Though the value of a service of a flying boat such as would be used on the service would be £50 to £60 a ton, it is a necessary provision that a rebate of some kind should be made to the owner of every 100 tons of mail and passengers to be replaced, and others provided in bad weather. This necessary creates a tendency to locate the boat from one island to the next, where such islands are to be found at convenient in-



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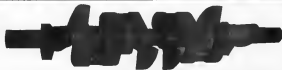
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